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Suppression of soil organic matter decomposition by gasoline and diesel as assessed by ^{13}C natural abundance

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ABSTRACT

Petroleum products are common contaminants in soils due to human activities. They are toxic for microorganisms and threat their functions, including decomposition of soil organic matter (SOM). The direct estimation of altered SOM decomposition – based on the CO_2 efflux – is impossible after petroleum contamination because petroleum decomposition also contributes to these CO_2 fluxes. We used the natural differences in the isotopic signature ($\delta^{13}C$) of SOM and of petroleum products to partition the total CO_2 for both sources and to analyse the suppression of SOM decomposition. The dynamics of ^{13}C fractionation during the mineralization of gasoline and diesel was measured during 42 days. The ^{13}C fractionation varied between −8.8‰ and +3.6‰ within the first 10 days, and stabilized thereafter at about −5.3‰ for gasoline and +3.2‰ for diesel. These ^{13}C fractionations and $\delta^{13}C$ values of CO_2 emitted from the soil were used to partition the total CO_2. Contamination with gasoline reduced the CO_2 efflux from SOM by a factor of 25 (from 151 to 6.1 mg C-CO_2 kg^{-1} soil during 42 days). The negative effect of diesel was much lower: the CO_2 efflux from SOM was decreased by less than a factor of 2. The strong effect of gasoline versus diesel reflects the lower absorption of gasoline to mineral particles and the development of a thin film on water surfaces, leading to toxicity for microorganisms. We conclude that the soil contamination by gasoline and diesel strongly decreased microbial functions and so, the degradation of native SOM.

1. Introduction

Petroleum compounds are frequent and significant pollutants of soils in many areas, especially at oil production and processing sites [1–3]. One of the few and comparatively inexpensive ways to reduce the concentration of such organic pollutants is their decomposition by native soil microorganisms. This decontamination approach is useful from both the environmental and economic standpoints [4–6]. The intrinsic microbial biodegradation of petroleum products involves their mineralization, transformation into nontoxic compounds, or long-term bonding on mineral particles and soil organic matter. Certain microorganisms can use petroleum compounds as a main source of carbon and electrons [7]. Numerous *in situ* studies have enabled selecting the most active microorganisms capable of biodegrading aliphatic and aromatic petroleum compounds. These include inter alia: *Planomicrobium chinense*, *Rhodococcus erythropolis, Micrococcus luteus, Pseudomonas putida, Pseudomonas fluorescens* and *Mycobacterium frederikbergense* [8–10].

Various parameters were measured in studies on biodegradation of petroleum compounds in soils, including degradation rates, microbial groups involved, changes in toxicity and completeness of decomposition of toxic substances. The most frequently used approaches are: i) analysis of enzyme activities, e.g. dehydrogenase activity [9]; ii) microbiological analysis of cell morphology, conidiophores and conidies, motility, Gram-reaction [11]; iii) chromatographic analysis of petroleum components and

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